Dynamic Evaluation Model and Application Methods for Engineering Machine Maintenance Quality

WANG Jian[1], *WANG Yan-feng*[1], *DAI Ling*[2], *WANG Xi*[1]

[1] Engineering Corps College of PLA, Xuzhou 221004, P. R. China

[2] Xuzhou Air Force College of PLA, Xuzhou 221000, P. R. China

Abstract: *It is an important content of equipment management to keep the engineering machine well. Based on the theory of component technology and grey related algorithm arithmetic, the requirements and procedures of engineering machine maintenance predicting process are analyzed, and a support object evaluation system is provided. The qualitative and quantitative indexes of evaluating process are fully taken into consideration to provide scientific methods and ways for proper evaluation and decision.*

Key words: engineering machine; maintenance quality; evaluating system; component technology; related algorithm arithmetic

1 Introduction

It is an important content of equipment management to keep the engineering machine support chain well. In addition, it can enhance the enterprise´s competition power and insure the triumph in market circumstance. The inherent quality of engineering machine is the key to machine maintenance, it is also important assurance to restore battle effectiveness. The combat readiness integrity and mission success of engineering machine are directly influenced by maintenance quality. So, improving maintenance quality and restoring battle effectiveness are the important tasks of machine technique support.

At present, it is a difficult task to find the way to control maintenance quality in current maintenance management. There are many problems on how to establish quality index system, to select quality control model and methods and to take measures for collecting and handling quality data etc.

The fast development of modern information performance, network performance and administrative skill can offer a reliable technological way for the automation and intelligence of engineering machine management. According to the variety, sharp difference, wide distribution of the engineering machine, the much better reliability, security, sharing and reusability would be given in the exploitation of the related management and evaluation system of engineering machine. The evaluation system can be applied to the distributed systematic environment resorted to distributed objects and module performance. Practically, the different department can quickly exploit different evaluation system for different purpose through assembling the suitable modules. An open and general evaluation and decision system of engineering machine management can be built up to provide objectively authentic result of evaluation and scientific bases for management [1,2].

2 Evaluation model set-up

2.1 Evaluation content

The evaluation system for the quality of engineering machine maintenance is a complex system, lying in a high dimensional discrete space. We can design a quality evaluation model for engineering machine maintenance, based on the fuzzy comprehensive evaluation principle, then we propose an index system for the evaluation and a method for weight assignment, construct a comparison and identification matrix for the evaluation, establish a set for evaluation results to be chosen and the subjection-function of the influence

Received 21 February 2012

factor and its evaluation set. Finally, taking engineering machine for an example, we give the primary and the secondary evaluation models for its repair quality, and analyze the evaluation results.

Quality evaluation is one of the critical techniques in modern maintenance process. The quality evaluation for modern maintenance presents the feature of multi-targets, multi-attributes and fuzzy attributes. Fuzzy analytic hierarchy process in maintenance evaluation is often applied, this approach can process both the linguistic and numeric maintenance quality attributes, it can calculate the linguistic maintenance quality attributes with the fuzzy analysis, and the results of numeric maintenance quality attributes are educed by calculating 'superposition'. The weight values of quality evaluation indexes and maintenance quality attributes are often determined by Analytic Hierarchy Process, the most maintenance might be chosen by the contentment analysis of evaluation result. The approach of evaluation being applied to practice and results, which is satisfactory, shows that the approach is reasonable and effective.

Maintenance quality review of engineering machine is an effective method to improve maintenance quality. The inefficient traditional maintenance review is not accord with modern yield requirement. The multiple system truss of maintenance review is constructed based on the primary characteristic and the requirements of maintenance review and the network technology. The mode of communication between client and server and the flow of maintenance review system based on networks are expatiated. According to different phases of review, the universal quality index system for evaluating the maintenance is established and the maintenance review system based on networks is realized by NetMeeting.

2.2 Applications´ process for evaluation model

Grey related algorithm model is examined according to the actual use of engineering machine. On the basis of the things that divide the standard of judging of the goal evaluated strictly, the quantitative analytical method is introduced on the basis of qualitative analysis. The influence factor and the establishment principle of the evaluation index to the performance state process evaluation and decision are analyzed; the main evaluation method, model and the determinate method of the factor weight in the model and index system are presented.

1) Set comparative array

Suppose the number of engineering machine evaluating is m, the indexes array of engineering machine i is shown as following

$$\{A_i\} = \{A_i(1), A_i(2), \cdots, A_i(N)\}$$
$$i = 1, 2, \cdots, m \quad (1)$$

Where $A_i(1), A_i(2), \cdots, A_i(N)$ is the value of optimized indexes. N is the total number of selected indexes

$$B_i(j) = \frac{A_i(j)}{A_0(j)} \quad (2)$$

Where $A_0(j)$ $(j = 1, 2, \cdots, N)$ is the value of referring to standard(ideal value or average) . So we get infinitude outline array after converting above formula

$$\{B_i\} = \{B_i(1), B_i(2), \cdots, B_i(N)\} \quad (3)$$

2) Set optimized reference array

The principle of setting optimized reference array is the value of each index in array must be the best value selected from the relevant indexes to each engineering machine type. As a sample in transportability if weight, height, width and length are minimum, the value are the best, in speed-ability if distance and speed are maximum, the value are the best. According to this principle the optimized reference array can be get

$$\{B_0\} = \{B_0(1), B_0(2), \cdots, B_0(N)\} \quad (4)$$

3) Set weight of each index

For the degree that each index influences maneuverability differently, the proportion of each index is adequately considered in the process of evaluation. To describe it, weight collection is introduced

$$\{D\} = \{D(1), D(2), \cdots, D(N)\} \quad (5)$$

4) Set related degree, adding weight of each index to optimized reference array

(1) Get related coefficient

In grey related analysis, the related coefficient is the value figuring degree adjacency between the value in array being evaluated and the corresponding value in

reference array. The bigger the related coefficient is, the higher the degree of adjacency is.

The related coefficient of index j of equipment type i can be get as following

$$\xi_i(j) = \frac{\min_i \min_j |B_0(j) - B_i(j)| + \rho \max_i \max_j |B_0(j) - B_i(j)|}{|B_0(j) - B_i(j)| + \rho \max_i \max_j |B_0(j) - B_i(j)|} \quad (6)$$

Where ρ is differentiated coefficient, its range is from 0 to 1, its common value is 0.5. The related coefficient of each index can be calculated using above formula. The array of related coefficient can be got

$$\{\xi_i\} = \{\xi_i(1), \xi_i(2), \cdots, \xi_i(N)\} \quad (7)$$

(2) Get related degree adding weight

According to the related coefficient considering, the weight of the related degree adding weight is calculated by considering the weight each index influencing maneuverability. The formula is as following

$$\gamma_i = \sum_{j=1}^{N} \xi_i(j) D_j \quad (8)$$

Where N is the num of evaluation indexes influencing maneuverability selected. Sorting related degree adding weight of index array of each engineering machine to optimized reference array it can be shown that the engineering machine maintenance quality of each type is good or bad.

3 Data structure design for evaluating system

Large-piece maintenance is one of the typical models of modern enterprises whose quality management is an important part of enterprises management. The development procedure of a quality-accepted system on the repair of engineering machine with power machine is often applied. The structure, function and design ideas of the system, and its database structure and security are also focused on the application of database technology in many fields, such as data management, expert system, the client centered design idea are also emphasized in management process [3].

3.1 System data structure

For the data structure of this system, see Table 1.

Table 1 System data structure

Equipment list	Component list	Workshop section list	Maintain name list	Running data list	Maintain knowledge list	Fault information list	Maintain file list
Equipment code	Equipment code	Workshop code	Maintain style code	Equipment code	Equipment code	Equipment code	Equipment code
Equipment name	Component code	Workshop name	Maintain style name	Component code	Component code	Component code	Component code
	Component name			Running time	Maintain style	Fault code	Maintain date
	Sort				Maintain date	Fault information code	Maintain style
					Average cycle		Scheme time
							Real time
							Maintain cause
							Consuse material

The system has widely adapting knowledge, and contains various machines´ technique data. So it increases the difficulty for computer to deduce form the complex database. It adds an intelligent database especially. Thus, the static database using for expressing the common knowledge while the intelligent database using for storing the knowledge which is selected and processed. The system searches in the intelligent database first then turn to the whole static database [2].

3.2 System principle framework

The system uses and/or tree to show the regular collection for the machine diagnosis. So as to clearly express the causalities among the machine fault. The main system is composed of expert and databases manage system (see Figure 1).

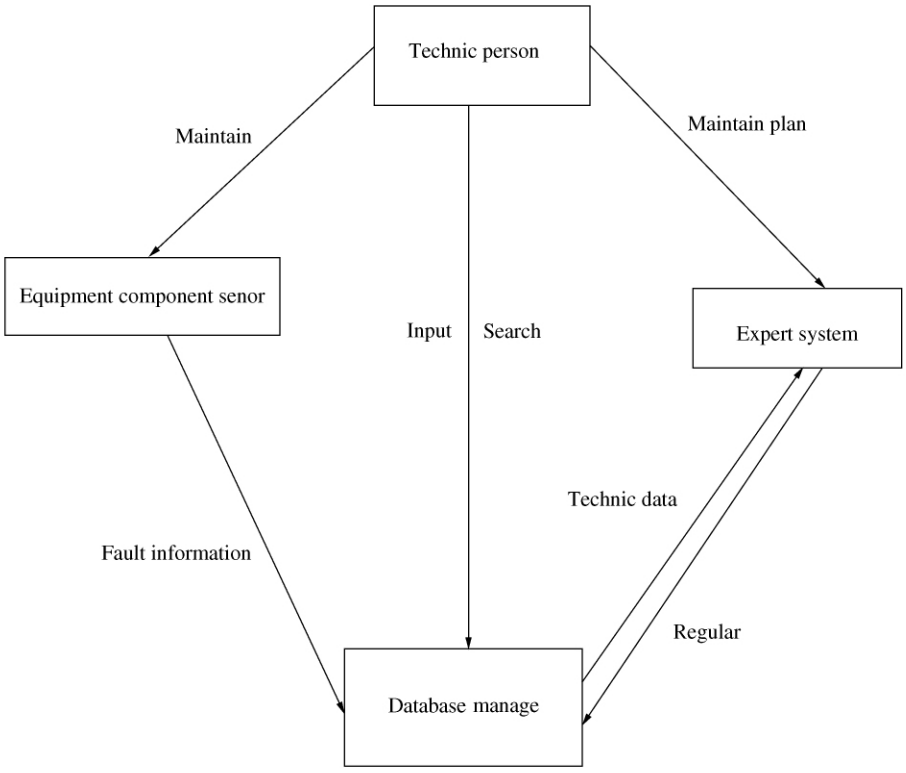

Figure 1 System principle framework

The actuality and developing direction of applying software on maintenance quality management is introduced and applied more and more. Design of quality evolution sub-system and construction and safety of system data are mainly researched in the applying process. According to the study state in this time, the quality acceptable system is developed, this system is tested by black-box method, the results indicate the system can meet the demands of stability, reliability and manipulation etc [4].

4 Reconstruction evaluation system design

In order to set up a universal maintenance quality evaluation system on engineering machine, the effective method is to develop the universal component for the system. The reusable technology based on the

COM is the mainstream to reuse the software. The COM is the basic component of the reusable software, which has nothing to do with the specific language and can be directly used to equip the software system as module but needn't program. When the application requires enhancing its function or altering, it needs nothing but to add, alter or replace the corresponding component. So the flexibility and the reconstructiblity are greatly enhanced. The main technology criteria in the component technology field at present are the Microsoft's COM/DCOM, OMG's CORBA and SUN's JavaBeans etc. The COM/DCOM technology was used in this system [5].

4.1 COM component/plug-in

1) COM component

COM component has an advantage of developing the universal component and has some features as follows: (1) plug and play: the component can be conveniently integrated in the application but do without modifying or recompiling the codes.

(2) with the interface as core: COM makes a fundamental distinction between interface definitions and their implementations. The interfaces implement the interaction with other component or application and the implementations are encapsulated in its interior. A component usually has a variety of interfaces. Each interface represents some properties and methods. What need the developers who are charged with integrating to do is to build component to connect with it.

Each COM has a GUID (Globally Unique Identifier), which is referred to at runtime with.

2) COM plug-in

In the maintenance quality evaluation system, the subroutines that need often to be displaced are implemented as the plug-ins. Owing to the capability of extending its father application's function, the maximum flexibility can be gotten without any alteration of the evaluation program by making every subroutine as plug-in. The plug-in interacts with its father application through a specific interface. Any module which can be added or communicate can be as plug-in, but the COM component is the most extensive.

4.2 The steps in creating a COM interface

1) Define the component's interface and declare it in the application; Decide how you want to provide marshaling support for your interface. All plug-ins' information such as GUID and name is stored in a datasheet so that the diagnosis application can recognize and call this kind of plug-in.

2) Design the plug-in management interface of the application. It provide marshaling support for your interfaces and configuring plug-in's loading or unloading, then stores the related information into the datasheet.

3) Design the fault diagnosis application's plug-in mechanism which can load necessary plug-in when visit the plug-in. The steps are as follows:

When need setup certain index to use some kind of inkling subroutine in new evaluation framework, we choose the plug-ins in the inkling subroutine information list and store their names in the inkling subroutine's data item which record the node in structured table. The evaluation component take its GUID and load, then call the method of the plug-in's interface according to the inkling subroutine name.

4.3 The steps in creating a COM interface

According to the demand of evaluation, the general model is designed with the use of COM module performance. The system package of engineering machine maintenance quality evaluation system is notified in Figure 2 [5].

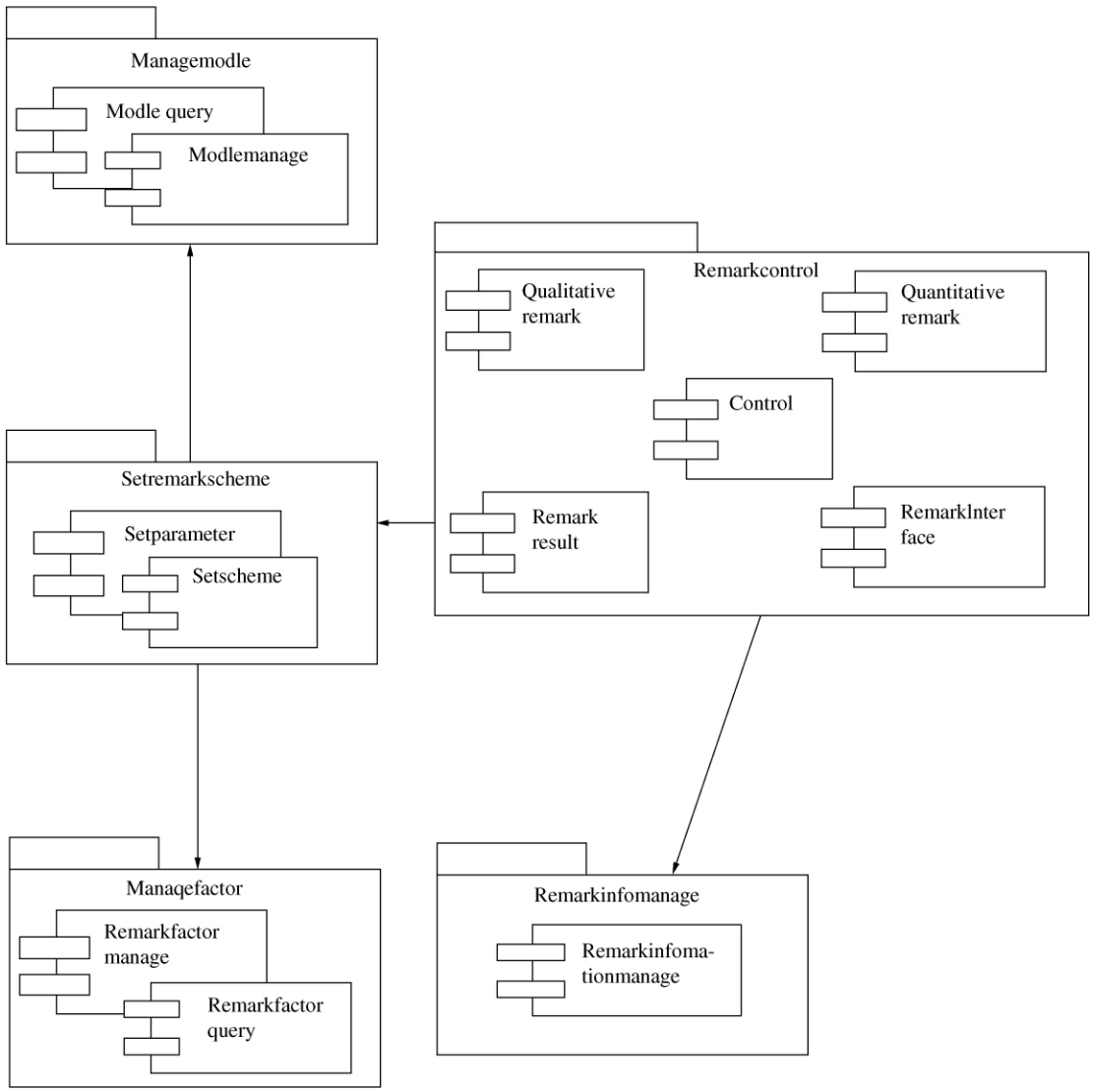

Figure 2 The system package of machine maintenance quality evaluation system

The concrete evaluation module is given based on the idea of platform + plug. With this method the flexibility and stability of the algorithm are ensured. Finally, the realization principle of algorithmic plug-in package and the common development operation are given. The general modules are classified according to the different role played in system.

The overall scheme of evaluation algorithmic model and the assemble method of describing algorithmic realization with the algorithm of evaluation are presented. The concrete evaluation algorithm and the corresponding algorithmic plug-in modules are given. The compute order for plug-in packages implement evaluation process is notified in Figure 3. Users can utilize these to build up the algorithm for evaluation system, which can ensure the stability and advance of evaluation algorithm and make maintaining and upgrading easy.

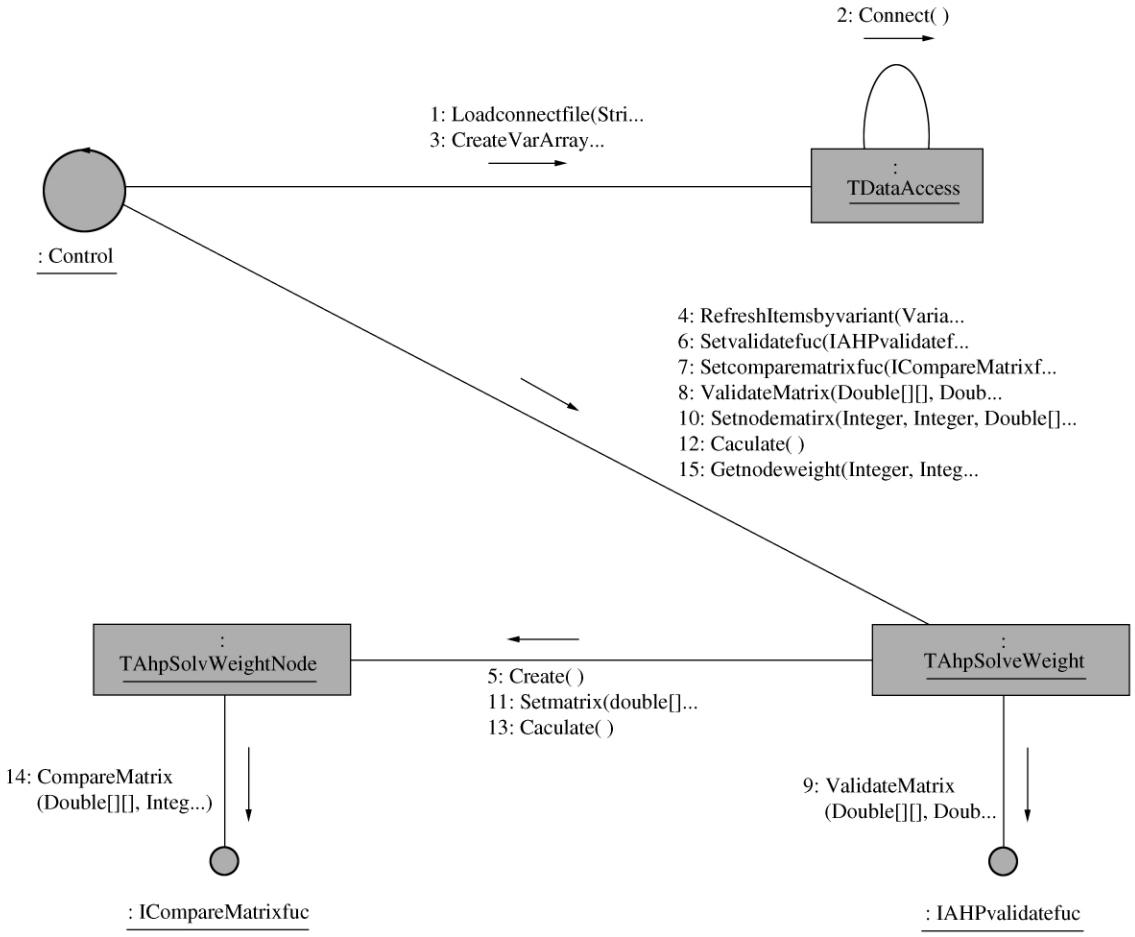

Figure 3 The compute order for plug-in packages implement evaluation process

The analysis and design of the index type module, the auxiliary type module, and module of the data obtain and the related plug-in packages are presented. The inside genus of all kinds of general modules is design and the transferring principle and procedure of all kinds of modules are discussed. In developing the data obtain type model, the descriptive file of evaluation data is studied which can obtain the data auxiliary. The general modules and evaluation algorithm consist of the whole development tool for evaluation system. The stability and flexibility are realized [6].

4 Conclusions

It is a multi-factor and multi-object decision process to predicting the maintenance of engineering machine. Based on the theory and method of component technology, the requirements and procedure of engineering machine maintenance predicting process are analyzed. According to the idea of precise management, a complete and reliable evaluation of the engineering machine's maintenance quality is made with the theory and method of fuzzy algorithm. The qualitative and quantitative indexes of evaluating process are fully taken into consideration. It can greatly improve the efficiency execution and solve the predicting and evaluation problem for engineering machine maintenance quality management.

References

[1] Choy K L, Lee W B, *Design of an intelligent supplier relationship management system: a hybrid case based neural network approach*. Expert Systems with Application, (24): 225 ~ 237, 2003

[2] Zhang G Q, Deng G S, Li Z H, *Prospect and technologies used in CBR*. Computer Engineer-

ing and Application,(20):52 ~ 55,2002(In Chinese)

[3] Liu Y, Li S Q, *Decision support system for maintenance management using bayesian networks*. International Journal of Plant Engineering and Management,12(3):131 ~ 138,2007 (In Chinese)

[4] Liao T W, Zhan Z H, Mount C R, *A case based reasoning system for identifying failure mechanisms*. Machine Design and Research, 19(1):53 ~ 56,2003 (In Chinese)

[5] Lou W J, Ying B, *Component technology about COM/DCOM/COM +*. Journal of Computer Applications,20(4):31 ~ 33,2000 (In Chinese)

[6] Li B, Tong S R, Bai J, *A model for the design process gene based on the extensible basic-element and the mutation of the design process gene*. International Journal of Plant Engineering and Management,16(2):1 ~ 5,2011 (In Chinese)

Brief Biographies

WANG Jian is a associate professor in Engineering Corps College. His research interests include reliability, maintenance and management of engineering equipment. njlgdwj@ sina. com

WANG Yan-feng is a professor in Engineering Corps College. His research interests include mechanical theory and design and mechatronic engineering.

DAI Ling is a docent in Xuzhou Air Force College. Her research interests include mechanical theory and design and mechatronic engineering.

WANG Xi is a associate professor in Engineering Corps college. Her research interests include mechanical theory and management of engineering equipment.